Title: Plastics

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Issue Date: 1940-11

Publisher: Ohio State University, College of Engineering

Citation: Ohio State Engineer, vol. 24, no. 1 (November, 1940), 12-13, 22-23.

URI: http://hdl.handle.net/1811/35740

PLASTICS

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Plastics is the term applied to any material that can be formed by the application of pressure, heat, or both and yet maintain its new shape after the stress is relieved. This definition is merely relative, since, under certain conditions all materials could be classed as plastic. Here it is taken to mean those materials that can be formed by the application of moderate stress but will not melt or soften under ordinary temperatures.

Plastic materials may be classified as thermoplastic and thermosetting. Thermoplastic refers to those materials that may be softened by heat and pressure again and again without losing this property no matter how many times the softening be repeated. Plastics that are termed thermosetting will not soften once they are set, but actually decompose before they can be melted. Both thermoplastic and thermosetting plastic are hard under ordinary conditions.

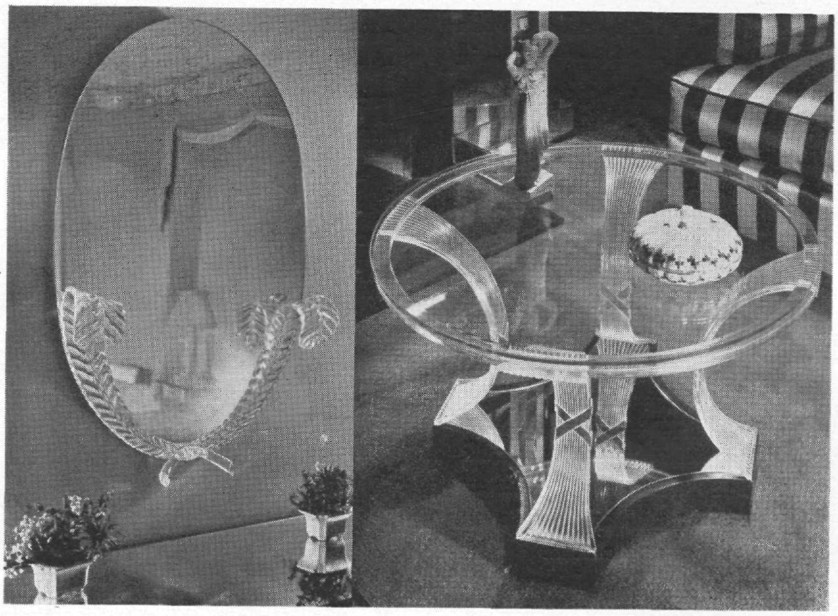
Due to their very nature all plastics have certain properties in common. These properties are several: high electrical insulation, relative inertness to chemical attack or corrosion, ease of formation into intricate shapes, high strength and hardness, versatility of finish and color, and reproducible uniformity.

Cellulose Nitrate Plastic

John Wesley Hyatt, an American, is credited with being the first to attempt to work with the thermoplastic cellulose nitrate as a mass rather than a solution. He obtained patents for the manufacture of celluloid from cellulose nitrate as early as 1869. Hyatt obtained his celluloid by gelatinizing cellulose nitrate with a solution of camphor in alcohol, mixing this material with desired fibers, working it between slightly heated rolls and forming in a press heated to 170 deg. Fahrenheit. The market for celluloid at that time was confined to combs, toothbrush handles, a few ornaments and similar articles. In the development of the motor car much celluloid was employed in sheet form as windows in the side curtains of early models. Celluloid remains even today one of the strongest and toughest of plastics. For this reason it is frequently incorporated with many of our later plastics to increase their strength.

The largest use of celluloid today is in the motion picture industry. Cellulose nitrate is the cheapest of the plastics that might be used for films, and until this cost factor is removed it will probably continue to be used. The most serious objection to cellulose nitrate is its high inflammability—not such an important defect in commercial use where precautions may be taken but an outstanding drawback to home use.

If for no other reason plastics would have made a name for itself for its contributions to safety glass. Cellulose nitrate lacquer was the first cement that could be used commercially to hold two pieces of glass together so that they would not fly and scatter when broken. Its serious drawback was its sensitivity to light. Windshields soon turned brown or became so full of bubbles it was impossible to see through them. As a



Courtesy Rohm & Haas Co.

The Uses of Plastics

More Uses Courtesy Bakelite Corp.

safety glass cement cellulose nitrate gave way to cellulose acetate which in turn was succeeded by the vinyl plastics used today.

Cellulose Acetate Plastic

Cellulose acetate is a thermoplastic formed from cellulose and acetic acid. It is superior to cellulose nitrate in non-inflammability and light resistance. The high cost of acetic acid and acetic anhydride has prevented cellulose acetate from invading many of the fields now held by the more cheaply produced cellulose nitrate. Cellulose acetate very early (1912) found use as a photographic film to replace the hazardous nitrate plastic. Cellulose acetate plastic can be made practically nonflammable, but as ordinarily formulated it will burn at a very slow rate. Another of cellulose acetate's outstanding properties is its resistance to impact. For this reason it is frequently used for cockpit enclosures on airplanes, protective goggles, car steering wheels, oil gages, and many other like products.

Phenol Formaldehyde Plastic

Accurately speaking neither cellulose nitrate nor acetate may be classified as a synthetic product since both require cellulose, a natural product, as their chief raw material. The most important of the truly synthetic plastics is the thermosetting plastic made from the coal tar product phenol and formaldehyde. It was known as far back as 1872 that the reaction between phenol and the aldehydes led to the formation of a plastic material, but phenolic plastic was of no importance for the next 35 years due to the inability of investigators to control the reaction beween the two compounds. In 1909 Baekeland received the so-called fifth-mol patent for the use of an alkaline catalyst (one-fifth mol catalyst per mol phenol) in controlling the phenol formaldehyde reaction. Until the expiration of the basic patents Bakelite was the only phenol formaldehyde plastic marketed. Phenolic plastic found wide application in the electric industry due to its excellent resistance to both electricity and heat. The dark color of phenol formaldehyde in the natural state prevented it from being pigmented to colors other than black or dull brown. This color limitation prevented it from being used for many articles where appearance is an important factor.

Urea Formaldehyde Plastic

Urea formaldehyde is a thermosetting plastic born of the union between urea and formaldehyde. Urea is obtained from ammonia and carbon dioxide while formaldehyde is made synthetically from carbon monoxide and hydrogen. Urea formaldehyde, a hard solid material, is thus made from four gases. These four gases are in turn produced from air, carbon and water—three of our most common raw materials giving us a useful plastic. Urea formaldehyde is, when pure, essentially water-white and translucent and, therefore, can be easily pigmented to any color of the rainbow or to a snowy white. Its chief drawback is that it is comparatively soft and scratches rather easily. This softness is largely overcome by the addition of fillers and other plastics. The most commonly used fillers are cotton, paper and wood flour.

The production of light pastel shades gives urea formaldehyde a distinct advantage over the dark phenol formaldehyde plastics and is the principal reason for its extensive application. Urea plastic has excellent diffusing qualities and is used extensively in lighting. Other uses include dishware, ash trays, buttons and ornamental objects requiring light shades.

Production

The mechanics of manufacture of all plastics is more or less similar. For example let us take phenol for-

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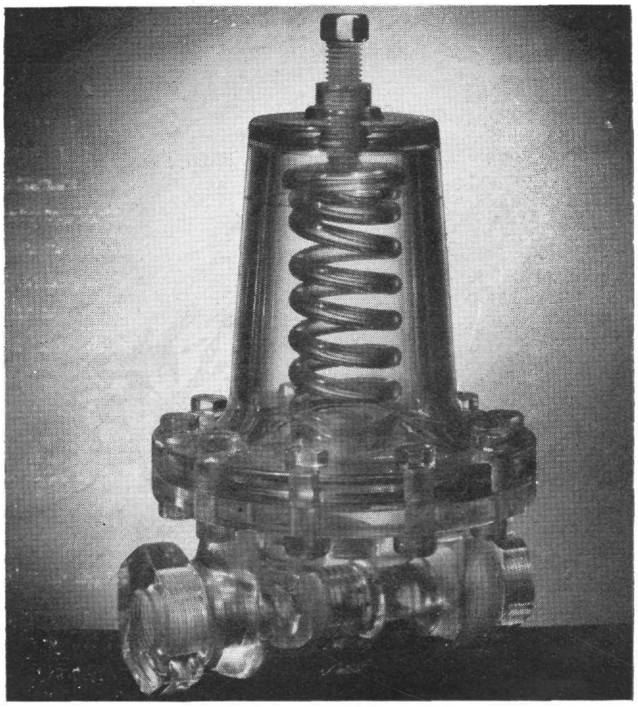
maldehyde and investigate the various steps necessary for its production.

Phenol and formaldehyde are allowed to react at a suitable temperature yielding a new substance which is a clear, amber-hued, resin-like solid. This solid can be melted or dissolved in solvents such as alcohol or acetone. This is referred to as the primary stage. Further application of heat would advance the plastic to a new chemical constituent making it permanently hard and resistant to acid attack. The plastic, in the primary stage, is ground into a powder and mixed with any desired fillers or coloring materials. To mold into a finished article, the powder is pressed into heated molds of the desired shape. The influence of the heat and pressure causes the powder to flux, completely filling the mold. A finished article duplicating the shape of the mold is withdrawn. It is resistant to both heat and chemical attack. Neither paint nor polish is necessary as it is possible to reproduce the finish of the mold.

For the average mold the temperature necessary to flux the powder ranges from 285 to 330 deg. Fahrenheit depending on the design of the object molded. The molding time will vary with the mold temperature and also with the material used. The modern practice of discharging the mold hot has greatly increased the speed of molding. The complete cycle for molding a thin walled object may be less than one minute. Ability to mold rapidly is one of the advantages of this type molding, since, for a given quantity of production less equipment is required.

Certain of the plastics may also be adapted to casting. This is carried out in a manner very similar to the casting of metal. The hot, molten plastic in the primary stage is poured directly into molds. These



An Innovation: The Plastic Valve

Courtesy Rohm & Haas Co.

Another Adaptation of Plastics
Courtesy of Bakelite

molds are usually lead and can be cheaply and easily made by dipping a master steel pattern into melted lead. After the plastic has solidified the molds are placed in curing ovens heated to 200 deg. Fahrenheit for several days. Plastic molded in this manner has identical properties to that molded by injecting powder into a heated mold. Casting is especially advantageous in the production of rather large pieces.

Supply

Plastic is a war material. Its use in telephones, airplane cockpit enclosures, electrical devices, automobile parts, radio parts, gas mask lenses and even gun parts give plastics a military value. In England at the present time due to World War II conditions plastics are replacing many articles formerly made of metal or wood. The invasion of Norway and the blockade of Sweden have cut off Britain's main supply of woodflour and paper pulp for fillers in phenolic and urea plastics. This shortage has caused increased imports of filler material from the United States and Canada. The importance attached by the British Government to the plastic industry is seen in the exemption of men of 23 years of age or over engaged in plastic or plastic goods manufacture from serving in the armed forces. This age limit was much higher at the start of the war.

On July 5, 1940 the President of the United States proclaimed a curtail on the free export of optically clear transparent plastics. With a few exceptions, and those minor ones, the United States has an abundance of the raw materials necessary for the manufacture of plastics. The chief raw materials required in plastic manufacture can be derived from air, water, coal, petroleum crudes, salt, sulphur, cellulose and limestone. No statistics are necessary to establish the generous supply of these products that nature has supplied within our boundaries.